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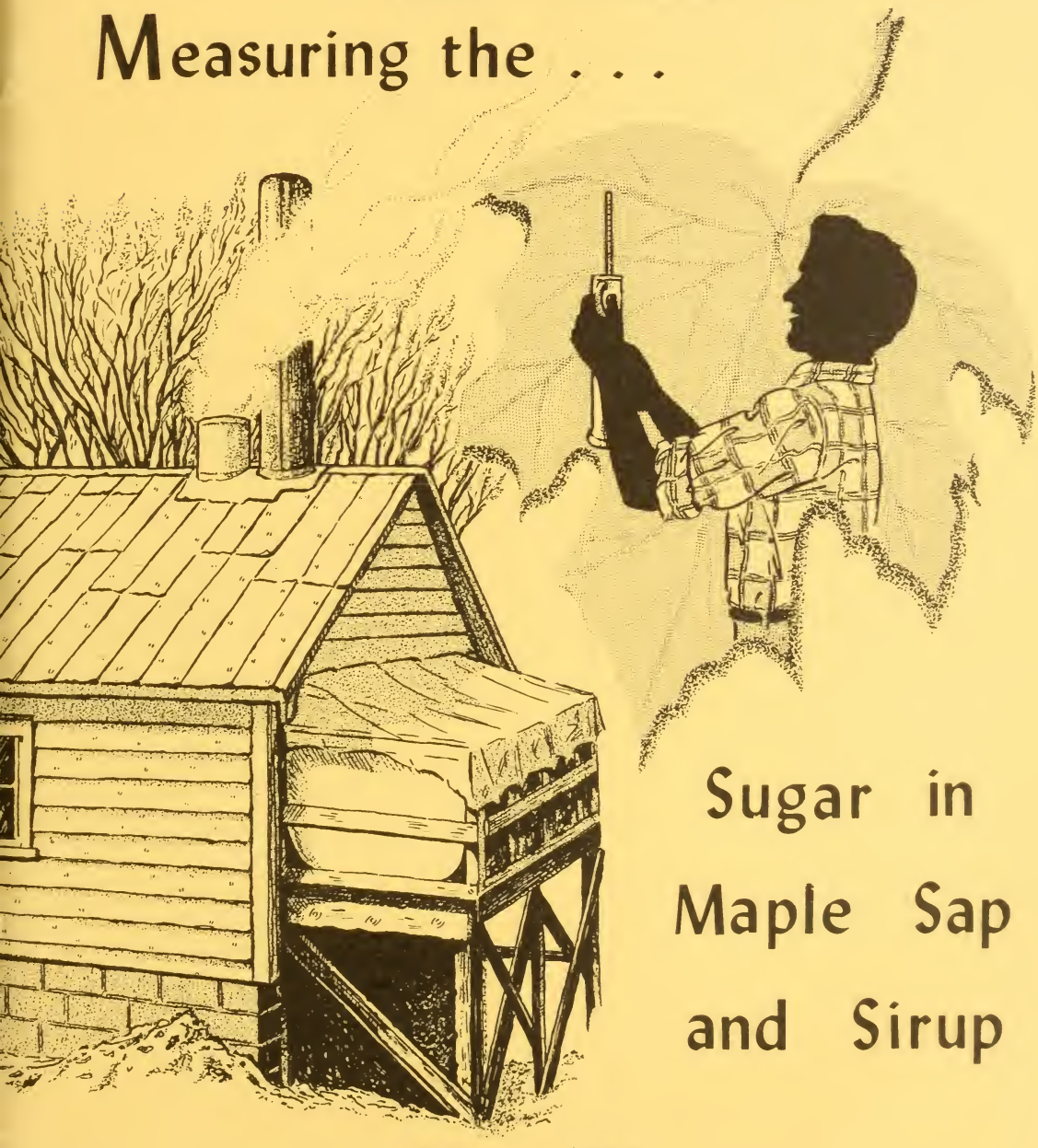
Measuring the . . .



Sugar in Maple Sap and Sirup

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ABSTRACT

This paper primarily gives detailed instructions on how to measure the amount of sugar in maple sap or sirup by means of a hydrometer. Also included are directions for diluting heavy sirups to make them only slightly above standard density and for establishing the sugar content of sap or sirup on the basis of elevation of boiling point of water.

This report is based on work done at the

EASTERN UTILIZATION RESEARCH AND DEVELOPMENT DIVISION

Philadelphia 18, Pa.

MEASURING THE SUGAR IN MAPLE SAP AND SIRUP

by

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Introduction

Maple sap and maple sirup are water solutions consisting mostly of dissolved sugar plus a very small amount of other material (such as salts of organic acids). The densities of sap and sirup, which vary with the amounts of dissolved solids, are usually expressed in terms of degrees Brix (percent sugar).

The density of all maple sirups must be maintained within very narrow limits, corresponding to a range of only 1.5° Brix (65.5°-67.0° Brix). If the density is below 65.5° Brix, it will not meet minimum State and Federal standards, it will taste watery (having a viscosity of less than 164 centipoises at 68° F.), and it will be more conducive to microbial growth. Sirup with densities above 67° Brix are supersaturated at room temperatures and will tend to crystallize on storage, forming unattractive crystalline deposits (rock candy) in the container. More important, these heavy sirups reduce the amount of sirup that could be produced from a given sap crop and result in a loss of income for the sirup producer. The measurement and adjustment of the density of all maple sirups that are for sale, therefore, is an absolute requirement.

The measurement of the density of maple sap is likewise important since it is from the known sugar content of the sap that sirup yields can be calculated. Since sap is becoming a marketable commodity whose value is based upon its sugar content, the precise measurement of its true sugar content in degrees Brix becomes essential.

The degrees Brix of sap or of sirup may be readily measured by hydrometry or by refractometry. Since hydrometry requires use of inexpensive instruments, the hydrometer, hydrometer cup, and a thermometer, it is the most commonly used method. The hydrometer must be a precision instrument that will cause an easily observable change in the depth at which the hydrometer stem floats. The scale contained in the hydrometer stem, whether it is in degrees Brix, degrees Baumé, or specific gravity, has no influence upon the sensitivity of the instrument itself. The Brix scale is preferable since its scale values give directly the percent solids content of the sap or sirup in terms of percent sugar.

Measurement of the density of sap or sirup by hydrometry is a relatively simple operation. Many users, however, incorrectly assume that the *observed* hydrometer readings are the *true* densities of the sap or sirup. This error occurs because they neglect to consider that sap and sirup are water solutions and therefore behave as water does, expanding and contracting with changes in temperature.

All hydrometers and refractometers made for use in this country are calibrated for use at 68° F. At this temperature, the observed hydrometer or refractometer values of the sap or sirup are the true values. If a given weight of either of these two solutions is heated to a temperature *above* 68° F., it will expand to a greater volume and will have an apparent (observed) density that is less than the true density. Likewise, a given weight of sap or sirup, when chilled to some temperature *below* 68° F., will contract to occupy a smaller volume and will have an apparent (observed) density greater than its true density.

To make exact density measurements, sensitive hydrometers that can be read with high precision must be used. The hydrometer stem, therefore, must be of sufficiently small diameter so that a change in the density of the sap or sirup equivalent to 0.1° Brix (percent sugar) will cause an observable change in the

depth at which the hydrometer stem floats, as measured at the intersection of the liquid surface and the hydrometer stem. Such a hydrometer will have a scale with 0.1° Brix graduations and will usually cover a range of 10° to 12° Brix. This will require a stem length of approximately 6-1/2 inches and an overall hydrometer length of about 13 inches. This type of hydrometer will require a hydrometer cup of at least 13 inches in depth.

Since the Brix scale gives densities of sap or sirup directly in terms of dissolved solids as percent sugar, it is ideally suited for use by the maple industry. Because many sirup hydrometers in use today have Baume scales, table 1 is included for the conversion of Baumé values (commonly called "points") to degrees Brix. To correct observed degrees Baume values ("points") for temperature effects, it is necessary to convert these Baumé values to degrees Brix by use of table 1.

Maple Sap -- Measuring its Solids (Sugar) Content

To determine accurately the sugar content of maple sap, use a hydrometer calibrated in 0.1° Brix. Place the sap in a hydrometer cup whose depth is equal to the overall length of the hydrometer and whose diameter is at least 1-1/2 times larger than the diameter of the hydrometer bulb. Fill the hydrometer cup to the top with sap, and gently set the hydrometer into the sap, allowing it to settle *unaided* until it comes to rest. Dropping or pushing the hydrometer into the liquid will submerge it too far and will coat the exposed stem with sap. This will add to the weight of the stem, causing in turn the observed Brix values to be too small. When the hydrometer comes to rest, at least 30 seconds after placing the hydrometer in the cup, lift the cup so that the liquid surface is at eye level. Read the marking on the hydrometer scale at the point of intersection of the hydrometer stem and the liquid surface. This value is the *observed* hydrometer reading (degrees Brix of the sap).

Conversion of observed Brix readings

to true density in degrees Brix

-MAPLE SAP-

Example 1. What is the true degrees Brix (percent sugar) of sap having an *observed* density of 2.3° Brix at a temperature of 35° F.?

Since the observed density is below 4.9° Brix, the correction to be used is in column 2 of table 2. Locate the temperature, 35° F., in column 1. Then, opposite to this in column 2 is 0.4° Brix, the correction to be subtracted *from* the observed degrees Brix. Therefore, the true density of this sap is 2.3° - 0.4°, or 1.9° Brix.

Example 2. What is the true degrees Brix of a sap sample having an *observed* reading of 5.5° Brix at 77° F.?

Since the observed density is above 4.9° Brix, the correction will be found in column 3 of table 2. Locate the temperature closest to 77° F. (75° F.) in column 1. Opposite to this in column 3 is 0.2° Brix, the correction to be added to the observed value. Therefore, the true density of this sap is 5.5° + 0.2°, or 5.7° Brix.

All hydrometers are calibrated for use at 68° F. This does not mean that sap must be heated or cooled until it is 68° F. before its density measurements can be made. Actually, the density can be measured at any temperature and the true density or degrees Brix calculated by application of the temperature correction factor. The temperature measurements of the sap should be made with a precision Fahrenheit thermometer calibrated in intervals of 1.0°, or preferably 0.5°.

Knowing the observed degrees Brix and the temperature of the sap, the correction for temperature effect can then be calculated. To avoid the necessity of making these calculations table 2 has been prepared, which shows the amount to be added to or subtracted from the *observed* degrees Brix readings to obtain the *true* degrees Brix of sap measured at some temperature other than 68° F. Since the amount of dissolved solids in sap affects the extent of expansion or contraction due to temperature change, two sets of corrections are given in table 2. Column 2 gives the corrections for sap having an observed Brix value between 0° and 4.9°, and column 3 includes corrections for sap having an observed Brix value between 5.0° and 9.9° (sap which has been concentrated by removal of water as ice or steam). The upper part of table 2 shows the corrections for sap at temperatures *below* 68° F. which must be subtracted from the observed hydrometer readings, and the lower part shows the corrections for sap at temperatures *above* 68° F., which must be added to the observed hydrometer readings. *(See examples on opposite page.)*

Maple Sirup -- Measuring its Solids (Sugar) Content

The effect of temperature on the density (degrees Brix) is more pronounced in sirup than in sap. Since sirup is more viscous than sap, the following precautions are even more important then they were for sap.- No sirup must be allowed on that part of the hydrometer stem that is exposed above the surface of the sirup being tested. The hydrometer must be clean and dry, it must be inserted with clean fingers, and must not be submerged too far and permitted to rise to its floating position. Sirup on the exposed stem of the hydrometer

will add weight to the hydrometer stem, causing the hydrometer to float too deep in the sirup so that the observed reading will be *low* and *incorrect*. The hydrometer will take longer to settle to its point of rest in sirup than in sap and so observed hydrometer readings, if made too soon, will be *high* and *incorrect*. Also, if the diameter of the hydrometer cup is too small, or if the hydrometer is floated too close to the wall of the cup, the movement of the hydrometer will be restricted and *incorrect* observed Brix values will be obtained.

To determine accurately the sugar content of maple sirup, use a hydrometer calibrated in 0.1° Brix. Place the sirup in a hydrometer cup whose depth is equal to the overall length of hydrometer and whose diameter is at least 1-1/2 times larger than the diameter of the hydrometer bulb. Fill the hydrometer cup to the top with sirup, and gently set the hydrometer into the sirup, allowing it to settle *unaided* until it comes to rest. Dropping or pushing the hydrometer into the liquid will submerge it too far and will coat the exposed stem with sirup. This will add to the weight of the stem, causing in turn the observed Brix values to be too small. When the hydrometer comes to rest, at least 30 seconds after placing the hydrometer in the cup, lift the cup so that the liquid surface is at eye level. Read the marking on the hydrometer scale at the point of intersection of the hydrometer stem and the liquid surface. This value is the *observed* hydrometer reading (degrees Brix of the sirup).

All hydrometers are calibrated for use at 68° F. This does not mean that sirup must be heated or cooled until it is 68° F. before its density measurement can be made. Actually, the density can be measured at any temperature and the true density or degrees Brix calculated, provided that the exact temperature of the sirup, at the time this reading was made, is known. The temperature measurements of the sirup should be made with a precision Fahrenheit thermometer calibrated in intervals of 1.0°, or preferably 0.5°. Knowing the *observed* degrees Brix and the temperature of the sirup, the correction for temperature effect can then be cal-

Conversion of observed Brix readings

to true density in degrees Brix

-MAPLE SIRUP-

Example 1. What is the true density, in degrees Brix, of sirup having an *observed* density of 65.9° Brix at 165° F.?

Since the observed reading is below 69.9° Brix, the correction to be used is in column 2 of table 3. Locate the temperature, 165° F., in column 1. Then, opposite to this in column 2 is 5.0° Brix, the correction to be *added* to the observed degrees Brix. Therefore, the true density of this sirup is 65.9° + 5.0°, or 70.9° Brix.

Example 2. What is the true degrees Brix of sirup having an *observed* reading of 61.0° Brix at 57° F.?

Since the observed reading is below 69.9° Brix, the correction to be used is in column 2 of table 3. Locate the temperature closest to 57° F. (55° F.) in column 1. Opposite to this in column 2 is 0.5° Brix, the correction to be *subtracted from* the observed degrees Brix. Therefore, the true density of this sirup is 61.0° - 0.5°, or 60.5° F.

culated. To avoid the necessity of making these calculations, table 3 has been prepared which shows the amount to be added to or subtracted from the *observed* degrees Brix readings to obtain the *true* degrees Brix of sirup measured at some temperature other than 68° F. Since the amount of dissolved solids in sirup affects the extent of expansion or contraction due to temperature change, two sets of corrections are given in table 3. Column 2 gives the corrections for sirup having an *observed* Brix value between 60.0° and 69.9°, and column 3 includes corrections for sirup having an observed Brix value above 69.9° Brix. The upper part of table 3 shows the corrections for sirup at temperatures *below* 68° F. which must be *subtracted* from the observed hydrometer readings, and the lower part shows the corrections for sirup at temperatures above 68° F. which must be *added* to the observed hydrometer reading. (See examples on page 7.)

The Density of Hot Sirup

Estimated by the "Hot Test" Method

The "hot test" is often used to judge whether or not the process of evaporating sap to sirup is completed. This is usually done by taking a hydrometer cup full of the boiling sirup and, as quickly as possible, measuring the sirup density with a hydrometer.

The testing of hot sirup (immediately after it is removed from the evaporator or finishing pan) is not a precise measurement. It is extremely difficult to make accurate hydrometer and temperature readings at the same time in sirup that is hotter than 180° F. because the sirup is undergoing rapid temperature changes.

From the time the hydrometer cup is filled with boiling sirup until the observed hydrometer reading is made, the sirup will have cooled several degrees. The amount of cooling will depend upon the length of time involved and the temperature of the air surrounding the hydrometer cup.

The "hot test" is made as follows: fill the hydrometer cup with boiling sirup from the evaporator or finishing pan. Immediately place the hydrometer in the sirup and, as soon as the hydrometer comes to rest, make the observed density reading. All operations should be performed as quickly as possible. If the observed hydrometer reading is between 58.8° and 59.1° Brix, the evaporation of the sap to standard sirup density is completed.

To make this "hot test" as precise as possible, the hot sirup temperature must be between 210° and 218° F. at the moment the hydrometer reading is made. To be sure that the sirup is in this temperature range, first determine the temperature of the hot sirup in the following way. Fill the hydrometer cup with boiling sirup. Place the hydrometer and a thermometer in the sirup. Then, instead of reading the hydrometer, measure the temperature as soon as the hydrometer comes to rest. Repeat this procedure and, if the two consecutive temperature readings are *not* obtained in the range of 210° to 218° F. *practice* speeding up the different setps of the operation until these temperatures are obtained at the time hydrometer readings would be made.

Adjustment of "Heavy Sirup" to Standard Density

Regardless of the cause of its formation, a heavy sirup represents a decrease in the potentiol number of gallons of sirup that can be made from a given quantity of sap. Sirup should, therefore, be adjusted to the proper density. The adjustment of "heavy sirup" to a lighter density can be calculated by the alligation procedure using Pearson's square. Since these calculations are rather complicated, table 4 has been compiled for finding directly the volume of water needed to adjust 100 pounds, or any part thereof, to 66° Brix, a density just slightly above standard density but which because of its much higher viscosity, is much more palatable.

The calculation for the adjustment of "heavy sirup" can be done accurately only after the true density in terms of degrees Brix has been determined (See page 5.)

Adjustment of "heavy sirup" to 66° Brix

Example 1. a 100-pound sample of heavy sirup has a true density of 69.7° Brix. How much water should be added to adjust this sirup to 66° Brix?

In table 4, under column 1, locate 69.7° Brix. Opposite to this in column 2 is 5 pints and 10 ounces, the amount of water to be added to the 100 pounds of heavy sirup to adjust it to 66° Brix.

Example 2. If only 12 pounds of the sirup in example 1 are being adjusted, how much water should be added?

Column 3 of table 4, opposite to 69.7° Brix of column 1, shows that 0.9 fluid ounces of water must be added to adjust 1 pound of this heavy sirup. For 12 pounds, 12 x 0.9, or 10.8, fluid ounces of water are required to adjust 12 pounds of 69.7° Brix sirup to 66° Brix.

Example 3. How much water should be added to 26 pounds of 68.2° Brix sirup in order to change its density to 66° Brix?

In table 4, under column 1, locate 68.2° Brix. Opposite to this, in column 3, find the value 0.53 fluid ounces, the amount of water to add to 1 pound of 68.2° Brix sirup. Then, 26 x 0.53, or 13.8, fluid ounces of water are required to adjust 26 pounds of 68.2° Brix sirup to 66° Brix.

Knowing the true degrees Brix of the sirup, the proper amount of water to be added to yield 66° Brix sirup can be obtained directly from column 2 or column 3 in table 4. After addition of the water, stir the sirup well to insure that the added water has been uniformly mixed with all the sirup. Then check the degrees Brix of the adjusted sirup to be sure that the resulting sirup is of the correct (66°) degrees Brix.

(See examples on opposite page.)

In all instances, test-check the density of sirup before packaging. To do this, fill a hydrometer cup, and, while keeping it covered to avoid loss of water due to evaporation, cool quickly to approximately room temperature. Then take the observed hydrometer as well as temperature readings and, by use of table 3, determine the true degrees Brix of the finished sirup.

Estimation of Approximate Degrees Brix of Maple Sirup from Elevation in Boiling Temperature

Table 5 was compiled to show the elevation of boiling temperature of sugar solutions (above that for water) over a concentration range of 0-73.5° Brix.

To use the table, determine the boiling temperature of pure water and then observe the boiling temperature of the partly evaporated sap. The *difference* between the two boiling points (note that the boiling temperature of water is always lower than that of the sugar solution) represents the elevation in boiling temperature. In table 5, the approximate sugar concentration can be read directly when the boiling point elevation is known.

(See examples on next page.)

Estimation of sirup density

from boiling temperature above that of water

Example 1. A producer wants to "draw off" sirup from the evaporator at about 40° Brix. At what boiling temperature should the sirup be removed if water boils at 210° F.?

In table 5, it is seen that at 40.5° Brix, the boiling temperature is elevated 2.0° F. Thus, when the boiling temperature rises to 212° F. (210° + 2° F.), the sap will be concentrated to approximately 40° Brix.

Example 2. A producer wants to concentrate the sap to 50° Brix in the evaporator before transferring it to the finishing pan. At what boiling temperature should the sirup be drawn off if water boils at 211.5° F.?

In table 5 it can be seen that the boiling temperature of 50.5° Brix solutions is 3.2° F. above the boiling point of water. Thus, 211.5° + 3.2°, or 214.7° F., is the boiling temperature of 50° Brix sirup.

Table 1. -- The equivalents of degrees Baumé in degrees Brix

Degrees		Degrees		Degrees	
Brix	Baumé	Brix	Baumé	Brix	Baumé
0.0	0.0	3.0	1.7	6.0	3.4
.1	.1	3.1	1.7	6.5	3.6
.2	.1	3.2	1.8	7.0	3.9
.3	.2	3.3	1.9	7.5	4.2
.4	.2	3.4	1.9	8.0	4.5
.5	.3	3.5	2.0	8.5	4.7
.6	.3	3.6	2.0	9.0	5.0
.7	.4	3.7	2.1	9.5	5.3
.8	.5	3.8	2.1	10.0	5.6
.9	.5	3.9	2.2	10.5	5.9
1.0	.6	4.0	2.2	11.0	6.1
1.1	.6	4.1	2.3	11.5	6.4
1.2	.7	4.2	2.4	12.0	6.7
1.3	.7	4.3	2.4	12.5	7.0
1.4	.8	4.4	2.5	13.0	7.2
1.5	.8	4.5	2.5	13.5	7.5
1.6	.9	4.6	2.6	14.0	7.8
1.7	1.0	4.7	2.6	14.5	8.1
1.8	1.0	4.8	2.7	15.0	8.3
1.9	1.1	4.9	2.7	15.5	8.6
2.0	1.1	5.0	2.8	16.0	8.9
2.1	1.2	5.1	2.9	16.5	9.2
2.2	1.2	5.2	2.9	17.0	9.5
2.3	1.3	5.3	3.0	17.5	9.7
2.4	1.3	5.4	3.0	18.0	10.0
2.5	1.4	5.5	3.1	18.5	10.3
2.6	1.5	5.6	3.1	19.0	10.6
2.7	1.5	5.7	3.2	19.5	10.8
2.8	1.6	5.8	3.2	20.0	11.1
2.9	1.6	5.9	3.3	20.5	11.4

Table 1. (Cont.) -- The equivalents of degrees Baumé in degrees Brix

Degrees Brix	Degrees Baumé	Degrees Brix	Degrees Baumé	Degrees Brix	Degrees Baumé
21.0	11.7	36.0	19.8	51.0	27.8
21.5	11.9	36.5	20.1	51.5	28.1
22.0	12.2	37.0	20.4	52.0	28.3
22.5	12.5	37.5	20.6	52.5	28.6
23.0	12.7	38.0	20.9	53.0	28.9
23.5	13.0	38.5	21.2	53.5	29.1
24.0	13.3	39.0	21.4	54.0	29.4
24.5	13.6	39.5	21.7	54.5	29.6
25.0	13.8	40.0	22.0	55.0	29.9
25.5	14.1	40.5	22.2	55.5	30.2
26.0	14.4	41.0	22.5	56.0	30.4
26.5	14.7	41.5	22.8	56.5	30.7
27.0	14.9	42.0	23.0	57.0	30.9
27.5	15.2	42.5	23.3	57.5	31.2
28.0	15.5	43.0	23.6	58.0	31.5
28.5	15.8	43.5	23.8	58.5	31.7
29.0	16.0	44.0	24.1	59.0	32.0
29.5	16.3	44.5	24.4	59.5	32.2
30.0	16.6	45.0	24.6	60.0	32.5
30.5	16.8	45.5	24.9	60.1	32.5
31.0	17.1	46.0	25.2	60.2	32.6
31.5	17.4	46.5	25.4	60.3	32.6
32.0	17.7	47.0	25.7	60.4	32.7
32.5	17.9	47.5	26.0	60.5	32.7
33.0	18.2	48.0	26.2	60.6	32.8
33.5	18.5	48.5	26.5	60.7	32.9
34.0	18.7	49.0	26.8	60.8	32.9
34.5	19.0	49.5	27.0	60.9	33.0
35.0	19.3	50.0	27.3	61.0	33.0
35.5	19.6	50.5	27.5	61.1	33.1

Table 1. (Cont.) -- The equivalents of degrees Baumé in degrees Brix

Degrees Brix	Degrees Baumé	Degrees Brix	Degrees Baumé	Degrees Brix	Degrees Baumé
61.2	33.1	64.2	34.6	67.2	36.2
61.3	33.2	64.3	34.7	67.3	36.2
61.4	33.2	64.4	34.7	67.4	36.3
61.5	33.3	64.5	34.8	67.5	36.3
61.6	33.3	64.6	34.8	67.6	36.4
61.7	33.4	64.7	34.9	67.7	36.4
61.8	33.4	64.8	34.9	67.8	36.5
61.9	33.5	64.9	35.0	67.9	36.5
62.0	33.5	65.0	35.0	68.0	36.6
62.1	33.6	65.1	35.1	68.1	36.6
62.2	33.6	65.2	35.1	68,2	36.7
62.3	33.7	65.3	35.2	68.3	36.7
62.4	33.7	65.4	35.2	68.4	36.8
62.5	33.8	65.5	35.3	68.5	36.8
62.6	33.8	65.6	35.3	68.6	36.9
62.7	33.9	65.7	35.4	68.7	36.9
62.8	33.9	65.8	35.5	68.8	37.0
62.9	34.0	65.9	35.5	68.9	37.0
63.0	34.0	66.0	35.6	69.0	37.1
63.1	34.1	66.1	35.6	69.1	37.1
63.2	34.1	66.2	35.7	69.2	37.2
63.3	34.2	66.3	35.7	69.3	37.2
63.4	34.2	66.4	35.8	69.4	37.3
63.5	34.3	66.5	35.8	69.5	37.3
63.6	34.3	66.6	35.9	69.6	37.4
63.7	34.4	66.7	35.9	69.7	37.4
63.8	34.4	66.8	36.0	69.8	37.5
63.9	34.5	66.9	36.0	69.9	37.5
64.0	34.5	67.0	36.1	70.0	37.6
64.1	34.6	67.1	36.1		

Table 2. -- Corrections to be applied to observed Brix readings to compensate for temperature effects*

-MAPLE SAP-

Temperature of sap in hydrometer cup Deg. F.	Observed Brix range (deg.)	
	0 - 4.9	5.0 - 9.9
	Correction to be *SUBTRACTED FROM* observed degrees Brix	
	Deg. Brix	Deg. Brix
32	0.4	0.5
35	.4	.5
40	.4	.5
45	.3	.4
50	.3	.4
55	.2	.3
60	.2	.2
65	.1	.1
68**	0	0
	Correction to be *ADDED TO* observed degrees Brix	
70	0.1	0.1
75	.2	.2
80	.4	.4

* If observed densities are in degrees Baumé, first convert them to degrees Brix (table 1), then apply the temperature corrections.

** 68° F. (approximately room temperature) is the exact temperature at which all hydrometers are calibrated

Table 3. -- Corrections to be applied to observed Brix readings to compensate for temperature effects*

-MAPLE SIRUP-

Temperature of sirup in hydrometer cup Deg. F.	*Observed Brix range (deg.)*	
	60.0 - 69.9	69.9 & higher
	Correction to be *SUBTRACTED FROM* observed degrees Brix	
	Deg. Brix	Deg. Brix
32	1.4	1.5
35	1.3	1.4
40	1.2	1.2
45	1.0	1.0
50	.8	.8
55	.5	.6
60	.3	.4
65	.1	.1
68**	.0	.0
	Correction to be *ADDED TO* observed degrees Brix	
70	0.1	0.1
75	.3	.3
80	.5	.5

(continued on next page)

Table 3. (Cont.) -- Corrections to be applied to observed Brix readings to compensate for temperature effects*

-MAPLE SIRUP-

Temperature of sirup in hydrometer cup Deg. F.	Observed Brix range (deg.)	
	60.0 - 69.9	69.9 & higher
	Correction to be *ADDED TO* observed degrees Brix	
	Deg. Brix	Deg. Brix
85	.8	.8
90	1.0	1.0
95	1.2	1.2
100	1.5	1.5
105	1.7	1.7
110	1.9	1.9
115	2.2	2.2
120	2.4	2.4
125	2.7	2.7
130	3.0	2.9
135	3.2	3.2
140	3.5	3.4
145	3.8	3.7
150	4.1	4.0
155	4.4	4.2
160	4.7	4.5
165	5.0	4.9
170	5.5	5.2
176	5.9	5.7

* If observed densities are in degrees Baumé, first convert them to degrees Brix (table 1), then apply the temperature corrections

** 68° F (approximately room temperature) is the exact temperature at which all hydrometers are calibrated.

Table 4. -- Water to be added to heavy sirup (66.1 - 70.0° Brix) to obtain 66° Brix (0.5° Brix above standard density)

True deg. Brix* of undiluted sirup	Amount of water to add to heavy sirup	
	Per 100 pounds	Per pound
66.1	0 pt., 2 oz.**	0.02 fl. oz.**
66.2	0 " 5 "	.05 " "
66.3	0 " 7 "	.07 " "
66.4	0 " 10 "	.10 " "
66.5	0 " 12 "	.12 " "
66.6	0 " 15 "	.15 " "
66.7	1 " 1 "	.17 " "
66.8	1 " 3 "	.19 " "
66.9	1 " 6 "	.22 " "
67.0	1 " 8 "	.24 " "
67.1	1 " 11 "	.27 " "
67.2	1 " 13 "	.29 " "
67.3	2 " 0 "	.32 " "
67.4	2 " 2 "	.34 " "
67.5	2 " 4 "	.36 " "
67.6	2 " 7 "	.39 " "
67.7	2 " 9 "	.41 " "
67.8	2 " 12 "	.44 " "
67.9	2 " 14 "	.46 " "
68.0	3 " 1 "	.49 " "

* Degress Brix of sirup after correction for temperature.

** For practical approximations, pints = pounds avoirdupois and fluid ounces = ounces avoirdupois.

(continued on next page)

Table 4. (Cont.) -- Water to be added to heavy sirup (66.1 - 70.0° Brix) to obtain 66° Brix (0.5° Brix above standard density)

True deg. Brix* of undiluted sirup	Amount of water to add to heavy sirup	
	Per 100 pounds	Per pound
68.1	3 pt., 3 oz.**	0.51 fl. oz.**
68.2	3 " 5 "	.53 " "
68.3	3 " 8 "	.56 " "
68.4	3 " 10 "	.58 " "
68.5	3 " 13 "	.61 " "
68.6	3 " 15 "	.63 " "
68.7	4 " 1 "	.65 " "
68.8	4 " 4 "	.68 " "
68.9	4 " 6 "	.70 " "
69.0	4 " 9 "	.73 " "
69.1	4 " 11 "	.75 " "
69.2	4 " 14 "	.78 " "
69.3	5 " 0 "	.80 " "
69.4	5 " 2 "	.82 " "
69.5	5 " 5 "	.85 " "
69.6	5 " 7 "	.87 " "
69.7	5 " 10 "	.90 " "
69.8	5 " 12 "	.92 " "
69.9	5 " 15 "	.95 " "
70.0	6 " 1 "	.97 " "

* Degrees Brix of sirup after correction for temperature.

** For practical approximations, pints = pounds avoirdupois and fluid ounces = ounces avoirdupois.

Table 5. -- Boiling temperature above that for water for solutions of different concentrations of sugar

Temperature elevation Deg. F.	Sugar solutions Pct.	Temperature elevation Deg. F.	Sugar solutions Pct.
0.0	0.0	5.0	59.7
0.2	7.5	5.2	60.4
0.4	13.8	5.5	61.5
0.6	19.0	5.6	62.0
0.8	23.4	5.8	62.5
1.0	27.1	5.9	62.9
1.2	30.3	6.1	63.4
1.4	33.4	6.4	64.4
1.6	36.0	6.6	64.9
1.8	38.4	6.9	65.6
2.0	40.5	7.1	66.0
2.2	42.5	7.3	66.5
2.4	44.3	7.5	67.0
2.6	46.0	8.0	68.0
2.8	47.7	8.2	68.5
3.0	49.0	8.5	69.0
3.2	50.4	8.8	69.5
3.4	51.6	9.1	70.0
3.6	52.8	9.5	70.5
3.8	53.9	9.9	71.0
4.0	54.9	10.4	71.6
4.2	55.9	10.7	72.1
4.4	56.9	11.1	72.5
4.6	57.8	11.5	73.0
4.8	58.8	12.0	73.5